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Uranium and radon in selected waters from the Quang Nam and Danang provinces – Central part of Vietnam

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Abstract. This work presents the uranium, radon isotopes, their activity ratio and main hazard elements (As, Al, Cd) in the water samples collected from the selected surface, ground and underground waters in Quang Nam and Da Nang provinces – median part of Vietnam. The surface water sources are presented by lake, stream and river, the groundwater sources are dug wells and the underground water sources are drill holes and thermal waters. Generally, the mineralization of the studied waters below 500 mg.L⁻¹ and the harmful elements such as arsenic, cadmium, and aluminium are around a few tenths of mg.L⁻¹. Both ²³⁴U and ²³⁸U activities in the studied water sources are low and vary from 0.47 to 27.6 mBq.L⁻¹ and from 0.6 to 15.0 mBq.L⁻¹, respectively. The values of the heavy elements and uranium isotopes are far lower than the WHO maximal recommended concentrations of the adequate elements in drinking water. Based on the measured data, uranium contents in the mentioned water types can be arranged as U_{rivers} < U_{stream} < U_{lakes} < U_{dig wells} < U_{thermal water} < U_{drill wells}. The uranium isotopes' activity ratio ranges from 0.69 to 2.31 with 1.26 on average. For the groundwaters the ratio scatters around one. Though there is the uranium deposit in the province of Quang Nam, it probably does not affect the uranium in the study waters.

Introduction

Da Nang and Quang Nam provinces are located in the middle part of Vietnam. Where have many landscapes. The region is characterized by the strong uplift of the Kon Tum - Da Lat massif and the deep subsidence of the continental shelf, creating mountainous terrain, hilly zones, plateaus, and plains where elevation gradually decreases from west to east. In the study area there are the Cu-De, Po-Ko, and Tra Bong faults. The faults have different trending directions including the sub-longitudes northeast-southwest, and northwest-southeast (Fig. 1). A major water storage formation is the Holocene diluvial formation. The Holocene diluvial occurs as the river deltas consisting of sand, mud, and gravel. The thickness of these formations varies from a few to a dozen meters with an area ranging from several tens to hundred square meters. The water hosting Pleistocene formation is distributed in all the region, with a thickness from 7 to 15 m. The main components of Pleistocene sediments are tiny grain sands with quartz, gravels, boulders, and mud. These formations are often poor in natural radionuclides. Finally, the water hosting Neogene sediments in Quang Nam province consists of mudstone, sandstone with gravels, conglomerates, and organic materials, having a thickness from 50 to 120 m. Due to the growth of the population, and rapid economic development, the demand of tap water has increased significantly. In addition, there are some uranium deposits in the neighboring area, the water could be contaminated with radioactive substances. The purposes of this study include (1) determining the ²³⁴U and ²³⁸U concentrations and their activity ratio (²³⁴U/²³⁸U) and radon activity in selected water sources; (2) attempting hydrological characterize the studied water resources; (3) accessing the safety regarding to the radiological and biochemical effects on human health due to the uranium isotopes and harmful elements absorbed by water consumption.

Sampling

The sampling was performed along the four major faults in the study area, where there are strongly fissured aquifers and dense population. The faults are located along the four lines F, S, H and K. The F and S lines are in Hoa Vang district in Da Nang province (Figure. 2a), and H and K lines are in Que Son and Nong Son districts in Quang Nam province (Figure 2b).

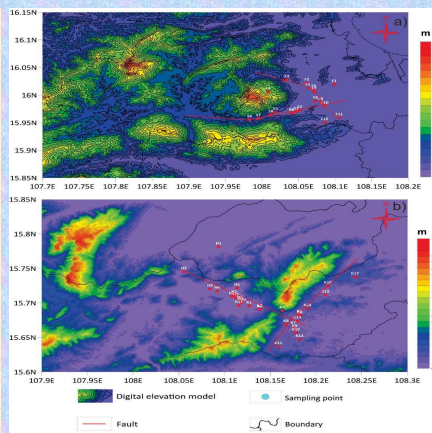


Figure 2: The sampling was performed along the four major faults in the study area



Figure 3. Sampling pictures

Measurements

Measurements of chemical and physical parameters

-Measurement of pH, Eh, Temperature by Hanna HI8314
-pH: Range 0 ÷ 14 with 0.01 of resolution
-Eh: Range: -1999 ÷ 1999 mV with 1 mV of resolution
-Temperature: Range: 0 ÷ 100 °C with 0.4 °C

Measurements of chemical composition

PerkinElmer Optima 7300 DV ICP-OES spectrometer

Measurements of Rn in water by RAD 7 Instrument.

This instrument can measure not only Rn but also its short life progeny Po-218 and Po-214.

Measurement of uranium isotopes by alpha spectrometry



Results

Reservoir	Ca [mg.L ⁻¹]		Mg [mg.L ⁻¹]		Na [mg.L ⁻¹]		K [mg.L ⁻¹]		As [mg.L ⁻¹]		Al [mg.L ⁻¹]		Cd [mg.L ⁻¹]	
	range	average	range	average	range	average	range	average	range	average	range	average	range	average
Lake (9)	1.08 ÷ 4.00	2.46	0.31 ÷ 1.55	1.00	2.2 ÷ 5.52	4.1	0.44 ÷ 1.79	1.14	0.0003 ÷ 0.001	0.001	0.001 ÷ 0.032	0.078	0.003 ÷ 0.04	0.013
Stream (10)	0.76 ÷ 4.17	2.75	0.23 ÷ 2.22	0.81	2.86 ÷ 5.81	4.1	0.80 ÷ 2.2	1.23	LLD ÷ 0.002	0.0005	0.001 ÷ 0.218	0.031	---	---
Dig well (6)	1.98 ÷ 19.6	5.93	0.12 ÷ 6.41	1.84	3.22 ÷ 24.96	7.63	0.7 ÷ 3.42	1.42	LLD ÷ 0.002	0.0005	LLD ÷ 0.008	0.002	---	---
Borehole (15)	1.16 ÷ 36.7	9.55	0.645 ÷ 9.45	3.65	2.17 ÷ 73.8	16.1	1.08 ÷ 6.76	2.86	---	---	LLD ÷ 0.11	0.08	---	---
Thermal (4)	1.54 ÷ 40.9	12.4	0.009 ÷ 1.22	0.32	68.2 ÷ 99.3	84.9	1.38 ÷ 12.3	4.92	LLD ÷ 0.008	0.003	0.003 ÷ 0.025	0.014	---	---

Discussions

- In general the mineralization of all the waters is below than 500 mg.L⁻¹ but it increases from the Surface waters to the groundwater and is reaches maximum for thermal water.
- The similar effect is also observed for the main elements of mineralization (Ca, Mg, Na, and K).
- The Rn concentration is below than 70 BqL⁻¹, excluding the point K10, in which the Rn reaches to 107 BqL⁻¹. So The study waters can be classified to the waters of low Radon. The point K10 can be the Rn trap, but this suggestion should be checked.
- Radon is lowest in surface water and medial in ground water and highest in underground water.
- The low Rn in waters is controlled by the geology of host rock formations such as sand, mud, and gravel.
- The uranium concentration is very low and ranges from a few tenths mBq/L to dozen mBq/L

Reservoir (samples)	Uranium [mBq.L ⁻¹]			Radon [Bq.L ⁻¹]			TDS (mg.L ⁻¹)		
	min	max	average	min	max	average	min	max	average
Lake (9)	0.56	8.39	4.30	0.26	6.50	1.69	14	71	34
Stream (10)	0.99	7.59	2.67	0.31	19.6	4.34	13	68	29
Dig well (6)	1.34	12.9	4.40	1.34	41.1	21.62	14	164	54
Borehole (15)	1.01	14.9	5.94	18.6	107	46.7	16	317	103
Thermal (4)	1.28	10.4	4.63	12.5	70.5	24.7	237	450	316

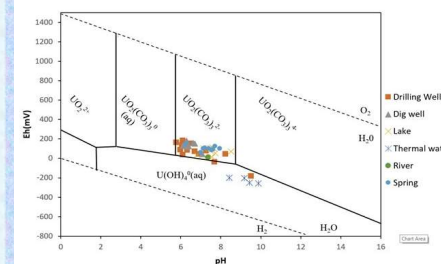


Figure 4. Eh vs pH diagram of the sampling waters

- ❖ Based on the diagram pH-Eh uranium occur as two negative carbonate. This condition ables uranium easily to dissolve, but in the all waters U is low.
- ❖ In the thermal water U occurs as +4 and precipitate, so thermal waters are poor in U

Conclusions

The mineralization of all the studied waters are below 500 mBq.L⁻¹ - sweet waters. Based on the mineralization in the waters can be arranged as: Stream < Lake < Ground < Thermal < Drill wells. There is no harmful elements such as As, Cd and Al. The concentration of uranium in the studied waters ranges from 0.6 to 14.9 mBqL⁻¹ with 4.4 mBqL⁻¹ of average. Uranium appears in the form UO₂(CO₃)₂²⁻ excluding in thermal water U(OH)₄. The maximum uranium concentration is far lower than that limit recommended by WHO for drinking water. Generally the Rn concentration in the waters is far below the level maximum recommended by EU for drinking water (100 BqL⁻¹). Rn increases with deep of the waters host formation. High Rn concentration at K10 could related to the geological trap in the fault zone. From the point of the heavy elements and radiological of view all the waters are safety for consumption.

Acknowledgment

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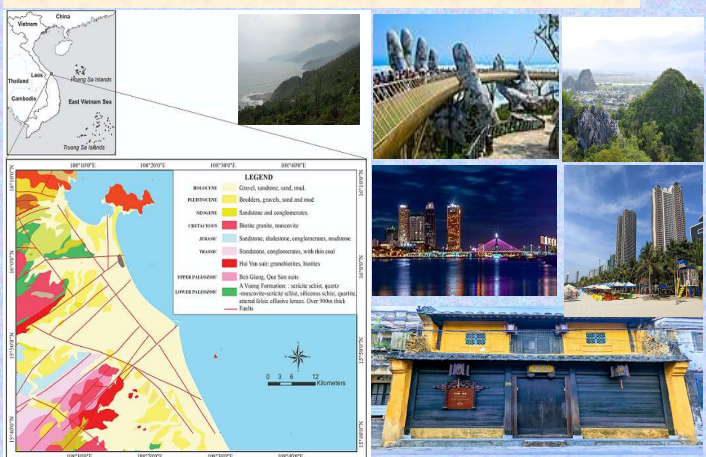


Figure 1. Localization and geology of Quang Nam - Da Nang provinces in Vietnam